

Revision of the genera *Acineria*, *Trimyema* and *Trochiliopsis* (Protozoa, Ciliophora)

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Synopsis

The genera *Acineria*, *Trimyema* and *Trochiliopsis* are reviewed. The revision is based on an investigation of each of the type-species, namely *Acineria incurvata* Dujardin, *Trimyema compressa* Lackey, and *Trochiliopsis opaca* Penard, which were found in a sewage-treatment plant. *Acineria* comprises three species; *A. incurvata*, *A. nasuta*, and *A. uncinata*. *A. acuta* is a synonym of *A. incurvata*. *Trimyema* comprises eight species; *T. alfredkahli*, *T. claviformis*, *T. compressa*, *T. echinometrae*, *T. kahli*, *T. marina*, *T. minuta* and *T. pleurispiralis* but *T. alfredkahli* and *T. claviformis* are perhaps synonyms of *T. marina*. *Trochiliopsis* is monotypic and new for the fauna of Austria. This genus is apparently closely related to the autochthonous soil ciliate *Stammeridium kahli*.

Zusammenfassung

Die Gattungen *Acineria*, *Trimyema* und *Trochiliopsis* werden revidiert. Die Revision basiert auf der Untersuchung der Typusarten, nämlich *Acineria incurvata* Dujardin, *Trimyema compressa* Lackey und *Trochiliopsis opaca* Penard, die in einer Kläranlage gefunden wurden. Die Gattung *Acineria* umfasst drei Arten; *A. incurvata*, *A. nasuta* und *A. uncinata*. *A. acuta* ist ein Synonym von *A. incurvata*. Von *Trimyema* sind acht Arten beschrieben; *T. alfredkahli*, *T. claviformis*, *T. compressa*, *T. echinometrae*, *T. kahli*, *T. marina*, *T. minuta* und *T. pleurispiralis*. *T. alfredkahli* und *T. claviformis* sind möglicherweise Synonyme von *T. marina*. *Trochiliopsis* ist monotypisch und neu für die Fauna Österreichs. Diese Gattung ist höchstwahrscheinlich nahe verwandt zum autochthonen Boden-Ciliaten *Stammeridium kahli*.

Introduction

Only few activated-sludge ciliates have been characterized by silver-staining techniques which is sometimes necessary for their correct identification. To overcome this deficiency, a project to redescribe the most frequently occurring species was begun. During these studies the poorly known type-species of the genera *Acineria*, *Trimyema*, and *Trochiliopsis* were found. They have been reinvestigated using modern techniques which provide a base upon which to revise these genera.

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Materials and Methods

Acineria incurvata, *Trimyema compressa*, and *Trochilopsis opaca* were obtained from activated sludge of the sewage-treatment plant at Aspach, Upper Austria.

Small samples of activated sludge were placed in glass petri-dishes where they remained without additional aeration. In such cultures a surprising succession and enrichment of ciliates often occurred. *Acineria incurvata* could also be cultured in tap water enriched with a crushed wheat grain which supported the growth of many small prey ciliates (*Dexiotricha*, *Uronema*).

The infraciliature was revealed with a protargol silver-staining method (Foissner, 1982). The silverline system was studied in specimens impregnated by a modified 'dry' silver-impregnation technique (Foissner, 1976). The oral structures of *Trimyema compressa* were impregnated by the pyridinated silver carbonate method of Fernandez-Galiano (1976) as improved by Augustin *et al.* (1984).

For scanning electron microscopy *Acineria* cells were fixed for 10 minutes in Parducz's solution (2% OsO₄ and concentrated Hg-sublimate solution, 4:1), rinsed in 0.05 M sodium cacodylate buffered at pH 6.3, dehydrated in an isopropyl alcohol series (60%, 70%, 80%, 90%, 100%, 100%, five minutes each) and put into a mixture of isopropyl alcohol (100%) and frigen 11 (2:1, 1:1, 1:2, five minutes each). Finally, cells were transferred into pure frigen 11 and critical point dried, using frigen 13. Specimens were gold-sputtered three times for six minutes each.

Each species was drawn from life as well as from impregnated specimens using a camera lucida for the latter. The drawings are only slightly diagrammatic. All statistical procedures follow methods described in Sokal & Rohlf (1981).

Genus *ACINERIA* Dujardin, 1841

DIAGNOSIS. Amphileptidae Bütschli, 1889 with (1) compressed oral slit anteriorly rolled up and overlapping to the left side forming (together with the anterior dorsal margin) an oblique spoon-like excavation, (2) three perioral kineties (one left and two right of the cytostome), (3) somatic kineties on the right side successively shortened along the cytostome, (4) oral slit measuring less than half of body length being located at the convex side of the tapering anterior. Freshwater and marine, prefers polysaprobic conditions.

TYPE-SPECIES. *Acineria incurvata* Dujardin, 1841

REMARKS. *Acineria* was mentioned for the first time by Dujardin (1840) in the family 'Trichodiens' but without any valid characterization. In 1841 he gave a rather vague diagnosis of the genus and of two species. Maupas (1883) criticized the unsatisfactory diagnosis and gave a better description of *Acineria incurvata* even noting the overlapping anterior end which is the main character of *Acineria*; nevertheless, he did not include this character in the diagnosis. How Maupas (1883) arrived at the conclusion that his species was the same as that described by Dujardin remains, however, inexplicable. It was only Kahl (1926) who used the real character of the overlapping dorsal end of the mouth to the left side to distinguish *Acineria* from the most closely related genus *Litonotus*. But there is no indication in the infraciliature that the dorsal margin and the left side coalesce as supposed by Kahl (1926, 1931). Thus, Kahl's interpretation that a part of the ciliated right side of the genus *Litonotus* has shifted over to the left side in *Acineria* is not supported by our investigations. We consider the rolled up anterior part of the mouth to be the reason for the anterior overlapping of the dorsal margin. The occurrence of somatic kineties on the left side, as stressed by Kahl (1926) is a weak distinctive character because this happens also, more or less pronounced, in the genera *Litonotus* and *Amphileptus* (Foissner, 1984).

Key to the species

- | | | | |
|----|---|---------------------|---|
| 1a | Single spherical macronucleus | <i>A. nasuta</i> | |
| 1b | Macronucleus in two parts with a single micronucleus between them | | 2 |
| 2a | Cytostome restricted to the rolled up anterior pole, right side with 3 somatic kineties, left side unciliated | <i>A. uncinata</i> | |
| 2b | Cytostome about one third of body length, 10-12 normally ciliated somatic kineties | <i>A. incurvata</i> | |

Descriptions of species

Acineria incurvata Dujardin, 1841

?*Trachelius anaticula* Ehrenberg, 1833

Acineria acuta Dujardin, 1841

?*Amphileptus anaticula* Claparède & Lachmann, 1859

Lionotus reversus Kahl, 1926

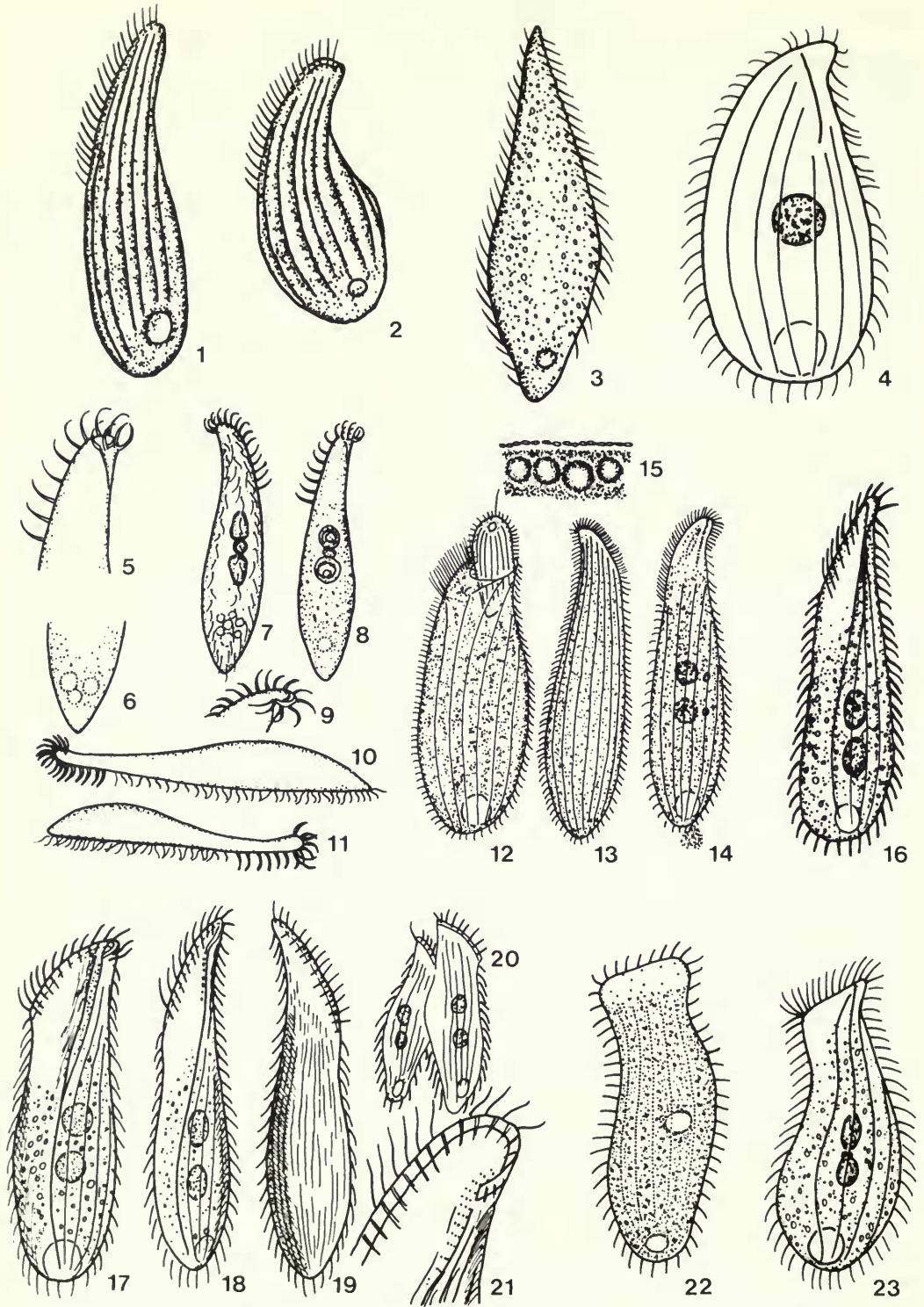
Amphileptus incurvatus Lepsi, 1926a

Lionotus lamella Fryd-Versavel *et al.*, 1975

NEOTYPE-SPECIMENS. Slide (protargol silver impregnated) of neotype-specimens has been deposited in the British Museum (Natural History) in London, reference number 1986:5:30:1.

REDESCRIPTION (Figs 1–3, 12–58, Table 1). Type species of the genus. Freshwater and marine. About 45–200 µm (Dujardin, 1841; Maupas, 1883; Kahl, 1926, 1928, 1931, 1933; Horváth & Kuhn, 1941; Bick, 1972; Foissner, 1977/78). Abnormal, giant individuals up to 500 µm showing most organelles duplicated observed by Foissner (1977/78) and probably by Lepsi (1965) (Figs 28–30). Body oblong, slightly contractile, laterally compressed, rounded posteriorly, narrowing anteriorly to a blunt point. Rather variable in shape (slender to wide and plump) depending on nutritional condition (Figs 31–34). Ventral side more or less convex, dorsal side straight or concave in the anterior, convex in the posterior region. Excavated region conspicuous, shining brightly. Anterior-most dorsal top somewhat refractive, due to the rolled up oral slit. Macronucleus in two spherical to ovoid parts with a single micronucleus between them. 1–3 micronuclei according to Maupas (1883). Macronuclear parts fuse during bipartition (Horváth & Kuhn, 1941) (Figs 38–42) and divide in the later fission stages (Kahl, 1926). Single contractile vacuole at the posterior pole, diameter about 7 µm, with 5–8 pores on the right lateral side (Horváth & Kuhn, 1941) (Fig. 43) which could not be seen in our slides. Cytoproct terminal, a slightly laterally located slit (Maupas, 1883; Kahl, 1926). Pellicle soft, flexible, with longitudinal furrows in which the cilia and bristles originate. Furrows disappear in well-fed individuals. Extrusomes straight to slightly fusiform (arrow-shaped according to Foissner, 1977/78), thin, about 4 µm long (2 µm according to Horváth & Kuhn, 1941), located along the cytostome, a small accumulation of them in the ventral side of the posterior end and even a few scattered throughout the body (Figs 48, 49). Cytoplasm of normally-fed specimens rather clear, containing some small colourless spheres. Carnivorous, feeds on small hymenostome ciliates, e.g. *Colpidium*, *Cyclidium*, *Glaucoma*, *Pseudocohnilembus*, *Loxoccephalus*, *Uronema* (Maupas, 1883; Lepsi, 1926a; Kahl, 1926, 1931; Buck, 1961; Struhal, 1969). Starved individuals feed even on 'cysts' of *Euglena viridis* (Horváth & Kuhn, 1941) and perhaps on bacteria (Lepsi, 1926a). Ingestion vacuoles rather large, dividing quickly into smaller food vacuoles (Horváth & Kuhn, 1941). Movement moderately quick, gliding on the bottom of the petri-dish or swimming in rotation along its longitudinal axis. Bipartition by transverse fission (Lepsi, 1926a; Horváth & Kuhn, 1941) (Figs 38–42). Opisthe almost spherical when it separates from the proter (Kahl, 1926; Horváth & Kuhn, 1941) (Fig. 40). Very small degenerative forms tend to conjugate; during this process the mouth of an individual fuses with the back of another (Kahl, 1926) (Fig. 20). Encystment frequently occurring when food is depleted (Horváth & Kuhn, 1941). Endocyst forms within an hour, later the macronuclear parts fuse to a worm-shaped product. Wall of ectocyst without visible structure. Cysts surrounded by some material which sticks them to the bottom of the culture dishes or to the bacterial film on the surface of the culture medium (Horváth & Kuhn, 1941) (Fig. 35).

Three different types of cilia: (1) normal cilia, about 10 µm, (2) short bristles, about 0.5–1.0 µm, (3) club-shaped bristles, up to 2.0 µm. Eleven longitudinal kineties with cilia type 1, about 8–9 of them on the right and about 3 on the left side. This is in accordance with the numbers given by Kahl (1926), Horváth & Kuhn (1941), and Fryd-Versavel *et al.* (1975). In addition to the normal somatic kineties the following are found on the more differentiated left side: (1) a single kinety with cilia type 2 located to the left of the brosse kinety and often extending only to the middle of the body, its posterior basal bodies less closely spaced, (2) one brosse row of obliquely arranged, paired bristles (cilia type 3) being posteriorly continued by a row of unciliated kinetosomes (or by kinetosomes



with very short bristles only), (3) one kinety consisting apically of 2–3 cilia of type 3 (probably constituting a rudimentary brosse row) and being continued by a few unciliated kinetosomes (about 5 in the anterior third and about 3 kinetosomes in the middle of the body). Kahl (1926, 1931) described the brosse as being built up of 3 rows of bristles (Fig. 21). Foissner (1977/78) observed only a file-shaped structure there, most probably suggested by the single row of paired brosse-bristles.

Cytostome more or less curved, anteriorly overlapping to the left side but not to the right as described by Lepsi (1926*a,b*, 1928). Perioral kinety 1 left of cytostome, with paired basal bodies along the mouth, however, only the anterior basal body each bearing cilia of type 2. Perioral kinety 2 and 3 to the right of the oral slit showing closely spaced basal bodies and constituting the so-called 'mane', a conspicuous compact ciliature. Perioral kinety 2 with paired basal bodies along the oral slit, the anterior basal body bears a cilium of type 1. This kinety appears unciliated post-orally. Perioral kinety 3 with single basal bodies but ciliated along the whole body with cilia type 1. Horváth & Kuhn (1941) misinterpreted the perioral kineties 2 and 3 as left and right perioral kineties. Their drawing, however, shows the correct situation, that is to say also perioral kinety 1 (Figs 43, 44). Fryd-Versavel *et al.* (1975) overlooked the perioral kinety 3 (Figs 45–47).

The silverline system is a linearly orientated fine-meshed lattice (Foissner, 1977/78) (Fig. 50a).

OCCURRENCE AND ECOLOGY. Dujardin (1841) found this species in a 20-day-old infusion of material from the Mediterranean Sea. Later it was recorded from the brackish waters of Oldesloe and Kiel (Kahl, 1928, 1933), from the Roumanian littoral of the Black Sea (Lepsi, 1926*a,b*, 1928; Tucolesco, 1962*a*) and from the periphyton of brackish and marine waters of Königshafen near List (Sylt, Germany) (Küstlers, 1974).

Some authors mentioned also terrestrial habitats (Radu & Tomescu, 1972; Tomescu, 1978), but a reliable record is not available (Foissner, 1987). The drawing made by Stella (1948), who claimed to have found *Acineria incurvata* in a pine forest, indicates that it was (probably) a member of the genus *Spathidium* (Fig. 22).

Acineria incurvata has been frequently found in strongly saprobic freshwater habitats, such as different sewage-loaded watercourses (Horváth & Kuhn, 1941; Buck, 1961; Bick, 1972; Madoni & Ghetti, 1977; Foissner, 1977/78), in *Sphaerotilus* tufts (Vašiček, 1964; Struhal, 1969), on the bottom of the river Elbe upstream from Hamburg (Grimm, 1968), in a cesspool (Kahl, 1926), and in sewage-treatment plants (trickling filters in good working order, aeration tanks) (Buck, 1961; Weninger, 1971; Madoni, 1981). Fryd-Versavel *et al.* (1975) found their '*Litonotus lamella*' in a pond in the year 1962. Šrámek-Hušek (1956, 1958) noted it as a true member of the 'Colpidietum colpodae'. Weninger (1971) found a decreasing abundance when nitrate or ammonium was added to sewage, whereas phosphate strongly increased its number.

The above data suggest that *Acineria incurvata* is a widely distributed polysaprobic euryhaline indicator species with a rather high tolerance of lack of oxygen and high concentrations of NH_4^+ .

Figs 1–23 *Acineria*.

Figs 1, 2 *Acineria incurvata* after Dujardin (1841).

Fig. 3 *Acineria acuta* after Dujardin (1841).

Fig. 4 *Acineria nasuta* after Lepsi (1962).

Figs 5–11 *Acineria uncinata* after Tucolesco (1962*a*). **5** Anterior pole. **6** Posterior pole, **7, 8** Right and left side. **9** Mouth and anterior pole overlapping towards the left side. **10** Ventral view. **11** Dorsal view.

Figs 12–23 *Acineria incurvata*. **12–15** After Maupas (1883). **12** An individual swallowing an *Uronema*. **13** Right side (Maupas called it dorsal view). **14** Left side (Maupas called it ventral view). **15** Pellicle. **16** After Kahl (1931), left side. **17–21** After Kahl (1926). **17, 18** Left side of different individuals. **19** Right side. **20** Conjugants. **21** Left anterior region. **22** After Stella (1948), probably a *Spathidium*. **23** After Buck (1961).

Table 1 Biometrical characterization of *Acineria incurvata*

Character ¹	\bar{x}	M	SD	SE	CV	Min	Max	n
Body, length	56.25	54.5	7.50	1.67	13.3	46.0	75.0	20
Body, width	15.50	16.0	2.01	0.45	13.0	12.0	19.0	20
Number of macronucleus parts	2.00	2.0	0.00	0.00	0.0	2.0	2.0	20
Macronucleus part, length	9.65	10.0	1.60	0.36	16.6	7.0	13.0	20
Macronucleus part, width	7.35	7.5	0.83	0.18	13.3	6.0	9.0	20
Number of micronuclei	1.00	1.0	0.00	0.00	0.0	1.0	1.0	20
Micronucleus, length	2.42	2.2	0.66	0.15	27.1	1.8	4.0	20
Micronucleus, width	2.12	2.0	0.47	0.11	22.3	1.6	3.6	20
Cytostome, length (measured as chord)	22.55	22.0	3.50	0.78	15.5	15.0	28.0	20
Distance from apex to posterior end of brosse	16.90	19.5	2.66	0.60	13.6	14.0	25.0	20
Number of brosse-bristles	41.20	40.0	4.18	0.93	10.1	34.0	48.0	20
Brosse-bristles, maximal length	1.72	1.8	0.24	0.05	14.3	1.2	2.0	20
Number of left perioral kineties	1.00	1.0	0.00	0.00	0.0	1.0	1.0	20
Number of right perioral kineties	2.00	2.0	0.00	0.00	0.0	2.0	2.0	20
Number of normally ciliated kineties (cilia type 1), perioral kineties excluded	10.85	11.0	0.59	0.13	5.4	10.0	12.0	20

¹All data are based on protargol silver impregnated specimens. All measurements in μm . Legend: \bar{x} , mean; M, median; SD, standard deviation; SE, standard error of mean; CV, coefficient of variation in %; Min, minimum; Max, maximum; n, sample size.

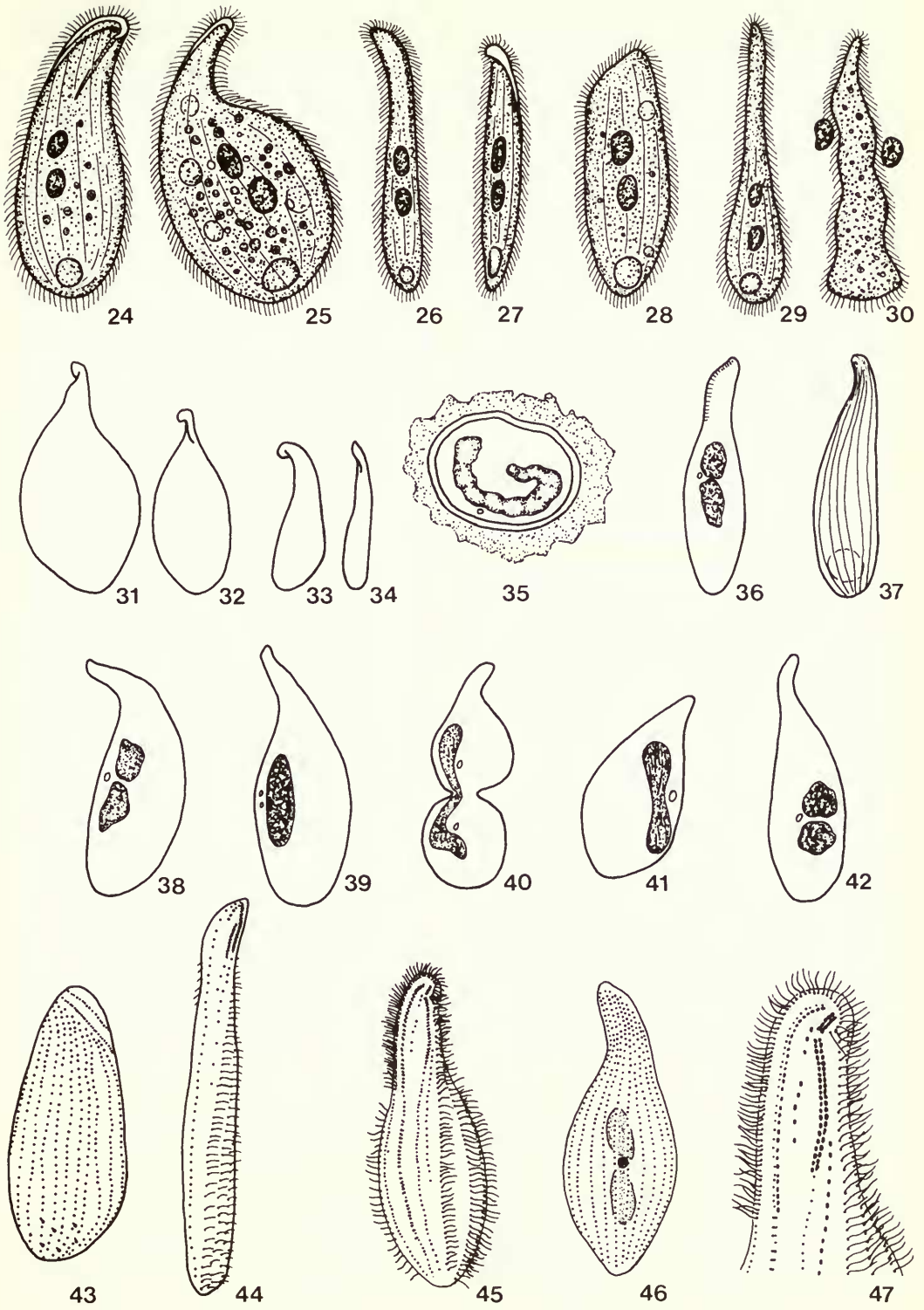
REMARKS. *Trachelius anaticula* Ehrenberg, 1833 is an older but unreliable synonym of this species. *Acineria acuta* Dujardin, 1841, which was observed in the water of a wheel-track in 1838, has been very insufficiently described and therefore cannot be discriminated from *Acineria incurvata*. Thus, *Acineria acuta* is here treated as synonym. *Amphileptus anaticula* perhaps is a synonym, too, but the figure given by Claparède & Lachmann (1859) shows an unidentifiable individual with a voluminous ingestion vacuole. The synonym *Lionotus reversus* Kahl, 1926 results *par lapsus*, since Kahl mentioned in a footnote that he had found Maupas' good description of *Acineria incurvata* just after having finished the manuscript. The synonym *Litonotus lamella* results from an obvious misidentification by Fryd-Versavel *et al.* (1975).

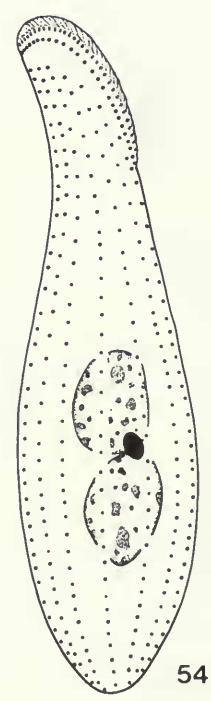
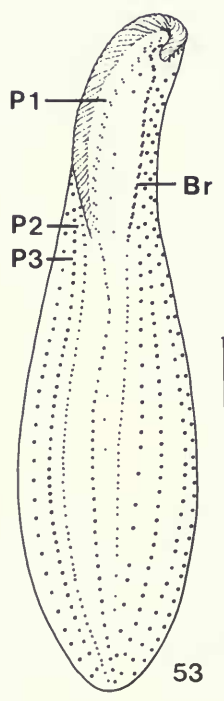
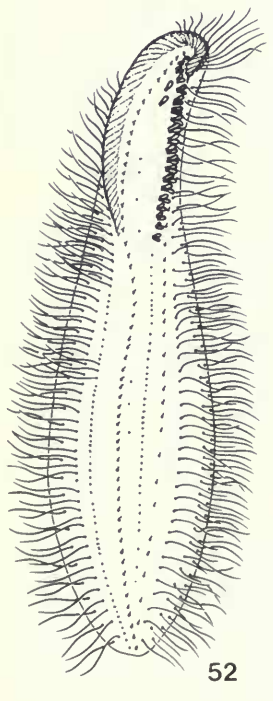
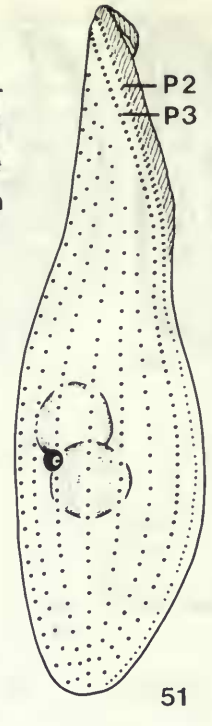
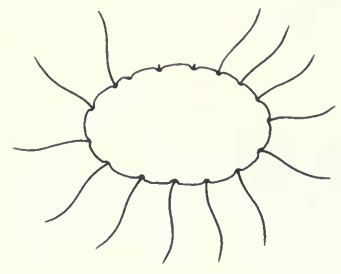
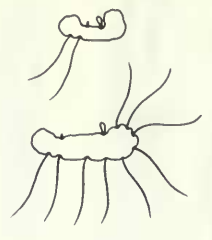
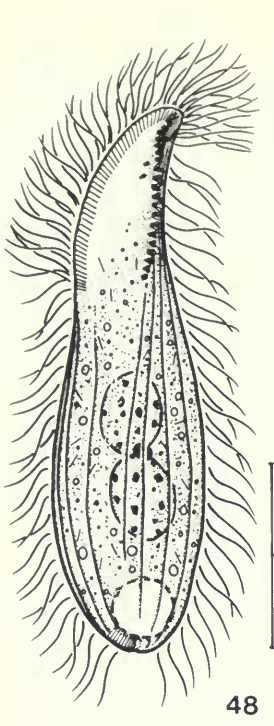
Acineria nasuta Lepsi, 1962

DIAGNOSIS (Fig. 4). Marine. About 90–100 μm long, rather wide. Only one single macronucleus. Pellicle with 5–6 distinct stripes. Postapical, to the right of the so-called 'nose' a peculiar line (perhaps the mouth) which is said to be characteristic of this species.

OCCURRENCE AND ECOLOGY. Only a few individuals were found in a raw culture of putrefying marine algae. In the same culture *Holophrya torquabilis* occurred in large numbers, probably serving as food for *Acineria*.

Figs 24–47 *Acineria incurvata*. **24–30** After Lepsi (1965). **24** Normal aspect. **25** *Trachelius*-like form. **26** Slender form, resembling *Spathidium*. **27** Degenerated individual resembling *Litonotus*. **28–30** Abnormal, degenerated forms. **31–44** After Horváth & Kuhn (1941). **31–34** Outlines of well-fed and starved specimens. **35** Cyst. **36** Left side, with extrusomes along the cytostome. **37** Right side, location of contractile vacuole and of kineties. **38–42** Bipartition. **43, 44** Infraciliature (right and left side) revealed by Bresslau's opalblue-technique. **45–47** After Fryd-Versavel *et al.* (1975), misidentified as *Litonotus lamella*. **45, 46** Infraciliature of left and right side. **47** Diagram of different types of cilia and bristles in the anterior region.







Figs 56–58 *Acineria incurvata*, scanning electron micrographs. **56** Total view of left side. **57** Anterior part with dorsal oral region rolled up forming a spoon-like excavation. Note the club-shaped brosse-bristles, the short bristles of the perial kinety 1, and the long cilia of perial kineties 2 and 3 (arrows). **58** Detail of anterior third with brosse-bristles, short bristles and normal cilia (arrows).

Figs 48–55 *Acineria incurvata*, originals. **48** Left side from life and according to scanning electron microscopic observations, scale = 20 μm . **49** Extrusome, length about 4 μm . **50** Reconstructed cross-sections in different regions of body. **50a** Silverline system in the oral region, dry silvered, after Foissner (1977/78). **51** Right side, infraciliature of a protargol silver stained specimen. P2, P3, perial kineties 2 and 3. **52** Left ventro-lateral view of a protargol silver stained specimen with different types of cilia and bristles according to SEM-observations. **53, 54** Infraciliature of the left ventro-lateral and the right dorso-lateral side of a protargol silver impregnated specimen. P1–3, perial kineties 1–3; Br, Brosse; scale = 30 μm . **55** Ventral view.

REMARKS. Lepsi (1962) assumed that this species, which has remained unmentioned since original description, could be a form of *A. incurvata* and mentioned some relationship with the genera *Chilophrya* and *Plagiocampa*. His figure and description are so incomplete that it is at present impossible to find any reliable affinity. The single macronucleus suggests that it is not an Amphileptidae, although he could have observed a dividing stage with fused macronucleus.

Acineria uncinata Tucolesco, 1962a

DIAGNOSIS (Figs 5–11). Brackish and freshwater. About 35–55 µm. Body lanceolate without lateral edge. Anterior pole overlapping towards the left side. Two spherical macronuclei showing a clearer zone at their central region. Sometimes a single, elongated, tapered nucleus. Contractile vacuole terminal, often surrounded by a group of smaller vacuoles. Cytostome a straight and short slit restricted to the rolled up anterior pole. Can therefore feed only on small prey (flagellates). Three somatic kineties on the right side with 20–22 cilia each. Cilia at the ventral margin of the anterior third transformed to regularly curved crotchets.

OCCURRENCE AND ECOLOGY. This species was found in summer 1954 in a small dirty brackish puddle near Lake Tekirghiol and in mesosaprobic freshwaters of Bucarest.

REMARKS. Tucolesco (1962a) separated this species from *A. incurvata* by the non-overlapping post-oral dorsal margin. However, in *A. incurvata* the situation is rather similar (page 199). Thus, we propose the following characters for discrimination from *A. incurvata*: the presence of only three somatic kineties on the right side, the (probably) unciliated left side, and the short oral slit being restricted to the anterior pole. Unmentioned since description. Note after proof reading: This is a valid species which we rediscovered recently! Redescription is in preparation.

Genus *TRIMYEMA* Lackey, 1925

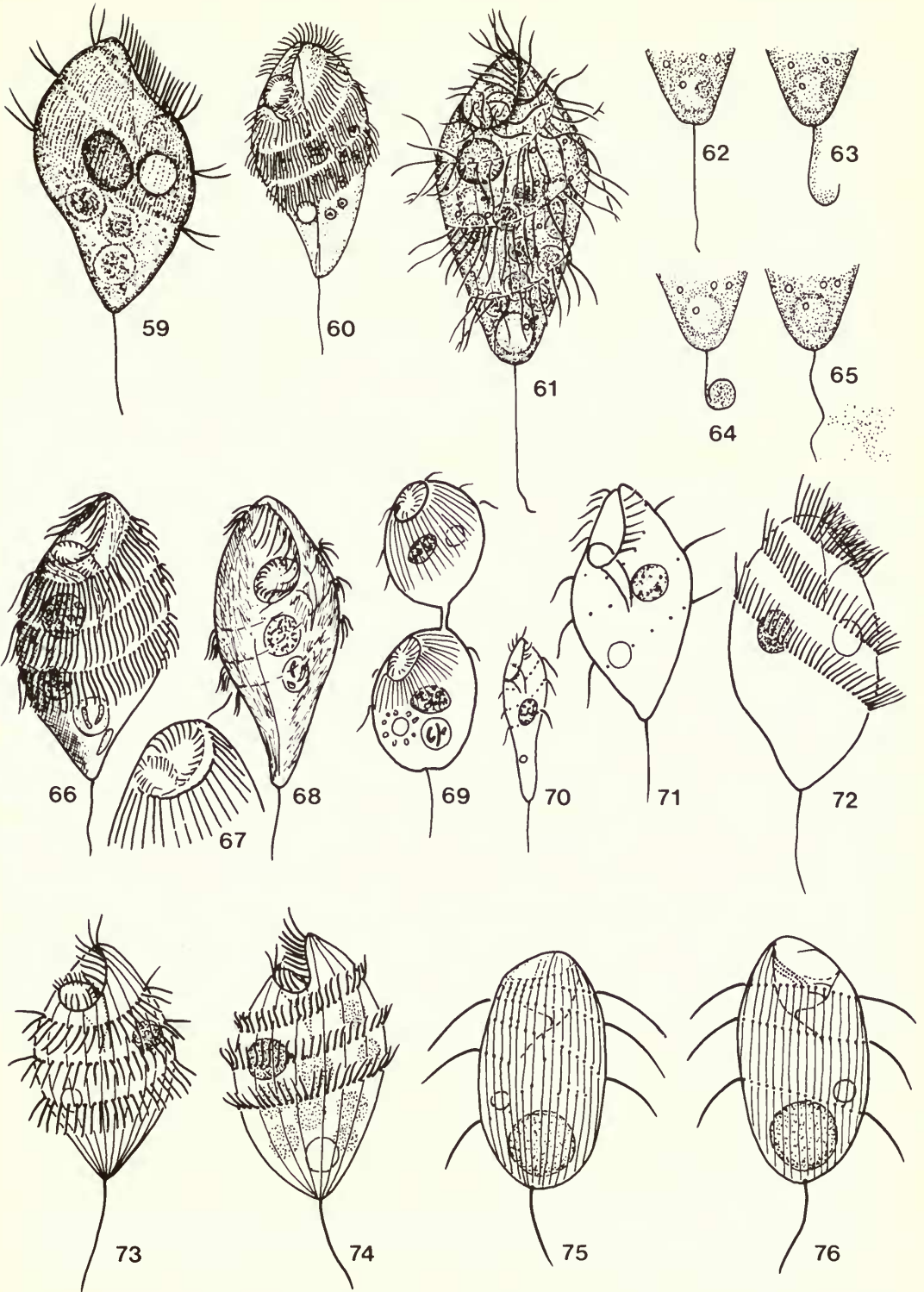
Sciadostoma Kahl, 1926

DIAGNOSIS. Trimyemidae Kahl, 1933 (syn. Sciadostomatidae Kahl, 1926) with vestibulum and cytostome near apical end. Vestibular ciliature consisting of three rows of cilia, two rather long ones arranged approximately in a semicircle at the left margin of the vestibulum and an inner rather short third row located near the cytostome at the posterior left of the vestibulum. Somatic ciliature in longitudinal kineties but arranged in a way that a more or less wide band of oblique spirals is formed. Prominent caudal cilium. Body small, mostly tapered at both ends. Free-living and endocommensally, freshwater and marine, polysaprobic.

TYPE-SPECIES. *Trimyema compressa* Lackey, 1925

REMARKS. There is much confusion about the exact orientation of the cell: dorsal, lateral, and ventral sides are often mixed up in descriptions. In addition some authors have given incorrect figures focusing the microscope on the lower surface of their specimens. Thus, they attained inverted figures (see explanations to figures). Most species of the genus *Trimyema* are only superficially described. The oral structures are known exactly only of *T. compressa* (Figs 83, 107) and

Figs 59–76 *Trimyema compressa*. 59 After Lackey (1925) (inverted). 60 After Wang & Nie (1935), left lateral view. 61–65 After Liebmann (1936). 61 Left ventro-lateral view. 62–65 Defecation by the aid of the caudal cilium. 66–69 After Kahl (1926). 66 Left lateral view. 67 Oral region during progressed bipartition. 68 Ventral side. 69 Bipartition. 70 After Kahl (1931), constant marine form, rather similar to *T. claviformis* described later. 71 After Kahl (1933), left lateral view. 72 After Pennak (1953) (inverted). 73 After Bick (1972), left lateral view. 74 After Sládeček (1972), left lateral view. 75, 76 After Schmall (1976), infraciliature of protargol silver stained specimens (inverted), ventral and dorsal view (Schmall called it dorsal and ventral view).



partly of *T. pleurispiralis* (Fig. 96) and *T. echinometrae* (Fig. 93). From the descriptions and our investigations we deduced the basic structure of the oral apparatus as described above (compare Fig. 107). Fauré-Fremiet (1962) and Borror (1972) obviously overlooked the short third vestibular kinety. Borror (1972) described only an inner and an outer 'polykinety'. Detcheva *et al.* (1981), however, showed in *T. compressa* electronmicroscopically that, despite their polykinetal appearance, the vestibular ciliary systems are not separate polykineties but are the anterior parts of the somatic kineties that are preceded by parasomal sacs and retain the same fibrillar systems as the somatic kinetosomes. Jankowski (1964*a,b*) gave no evidence for his statement that there were four vestibular kineties in *T. compressa*.

Encystment is unknown in this genus. Czapik (1975*a*) noted that even starved specimens (of *T. compressa*) die without forming cysts. Morphogenesis has not yet been exactly studied. However, the oral apparatus is supposed to reduce before cell division, because during division both proter and opisthe show the same state of development of the oral apparatus (Kahl, 1926) (Figs 67, 69).

The silverline system has been demonstrated only in *T. compressa* (Klein, 1930; Fauré-Fremiet, 1962; Jankowski, 1964*a,b*; Czapik, 1975*a*). Klein (1930) gave the description that best agrees with our observations (Figs 106, 110). But he did not draw the transverse silver lines connecting the longitudinal lines in the region of the ciliary spirals. The granules located at and in the silverlines (Fig. 110) have been said to be mucocysts ('Relationskörper') or rudimentary basal bodies (Klein, 1930). However, the electronmicroscopic investigation shows only mucocysts (Detcheva *et al.*, 1981).

The exact taxonomic position of the genus is still unclear. Kahl (1926) created a new family for the rather special helical ciliature. This author, Corliss (1979), and Curds (1982) included the family in the order Trichostomatida Bütschli, 1889. Fauré-Fremiet (1962) noted that the family Trimyemidae indeed presents one of numerous possibilities existing in the order to use the anterior-most somatic kineties for building up a vestibular ciliature. In addition, he indicated possible affinities of *Trimyema* with *Mycterothrix* and *Maryna*, which are now 'good' colpodids (Foissner, 1985*a*). Jankowski (1980) erected the new order Trimyemida (*incertae sedis*) giving no reasons for this decision. On the contrary, Detcheva *et al.* (1981) stated that *Trimyema* is a member of the Vestibulifera and that the Trimyemidae show the same general type of vestibular architecture as the Plagiopylidae and the Coelosomidae. However, a more reasonable classification demands further investigations especially on the morphogenetic processes.

Ruinen (1938) is wrong in transferring *Palmarium salinum* Gajevskaja, 1925 to the genus *Trimyema*, since *Palmarium* is illustrated as having an adoral zone of membranelles (Figs 97–101) (Borror, 1972).

Trimyema pura (Ehrenberg) is listed by Curds (1975) as a species occurring in percolating filters and in activated sludge. We suppose that this species has been described as *Trichoda pura* Ehrenberg, 1831, which according to Corliss & Dougherty (1967) is a synonym of *Tetrahymena pyriformis*.

Lackey (1925) classified *Trimyema* as female using the latin ending -a for his species *T. compressa*. Since we could not find any greek word comparable to 'myema' from which the name of the genus and its sex could be derived we accept Lackey's proposal of the sex. This, however, requires the endings of *T. claviforme*, *T. marinum*, *T. minutum*, and *T. pleurispirale* to be emended (see below).

Key to the species

- | | | |
|----|---|---------------------|
| 1a | 3 somatic ciliary spirals | 2 |
| 1b | Usually more than 3 somatic ciliary spirals | 3 |
| 2a | Posterior end of body tapered, length 25–65 µm | <i>T. compressa</i> |
| 2b | Posterior end of body broadly rounded, prominent beak-like pharynx opening, length c. 20 µm | <i>T. minuta</i> |
| 3a | Body broadly oval, width c. half length of body | 4 |
| 3b | Body rather slender, fusiform or oblong, width much less than half length of body | 5 |

- 4a 4(–6) somatic ciliary spirals restricted to the anterior half of body, length *c.* 20–45 μm *T. pleurispiralis*
- 4b 7 somatic ciliary spirals restricted to the anterior half of body, length *c.* 25–40 μm , endocommensally in sea-urchins *T. echinometrae*
- 5a Body club-shaped, thickened in the anterior region and slender in the posterior region, length *c.* 40 μm , (not totally reliable species!) *T. claviformis*
- 5b Body not club-shaped 6
- 6a Shape of body obviously asymmetric, tapered at both ends, anterior pole bent to the right, posterior pole bent to the left, peristome measures *c.* one third of cell length *T. kahli*
- 6b Shape of body symmetrical, slender fusiform to slender oblong 7
- 7a Body length *c.* 40 μm , peristome measures *c.* one fourth of body. *T. marina*
- 7b Body length *c.* 60 μm , peristome measures less than one fourth of body (not totally reliable species!) *T. alfredkahli*

Descriptions of species

Trimyema compressa Lackey, 1925

Sciadostoma difficile Kahl, 1926

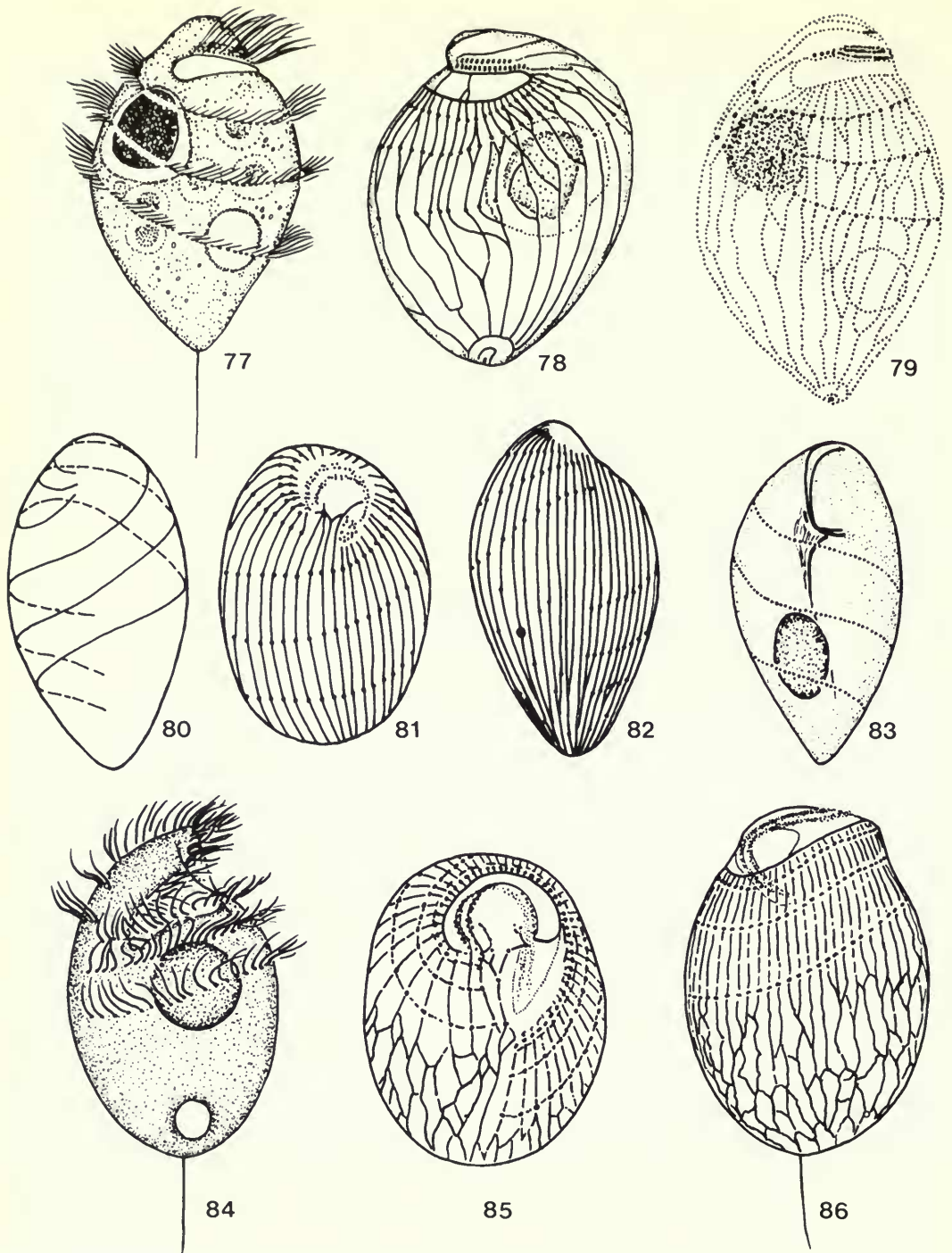
Trimyema compressum Kahl, 1933

Trimyema marinum Fauré-Fremiet, 1962

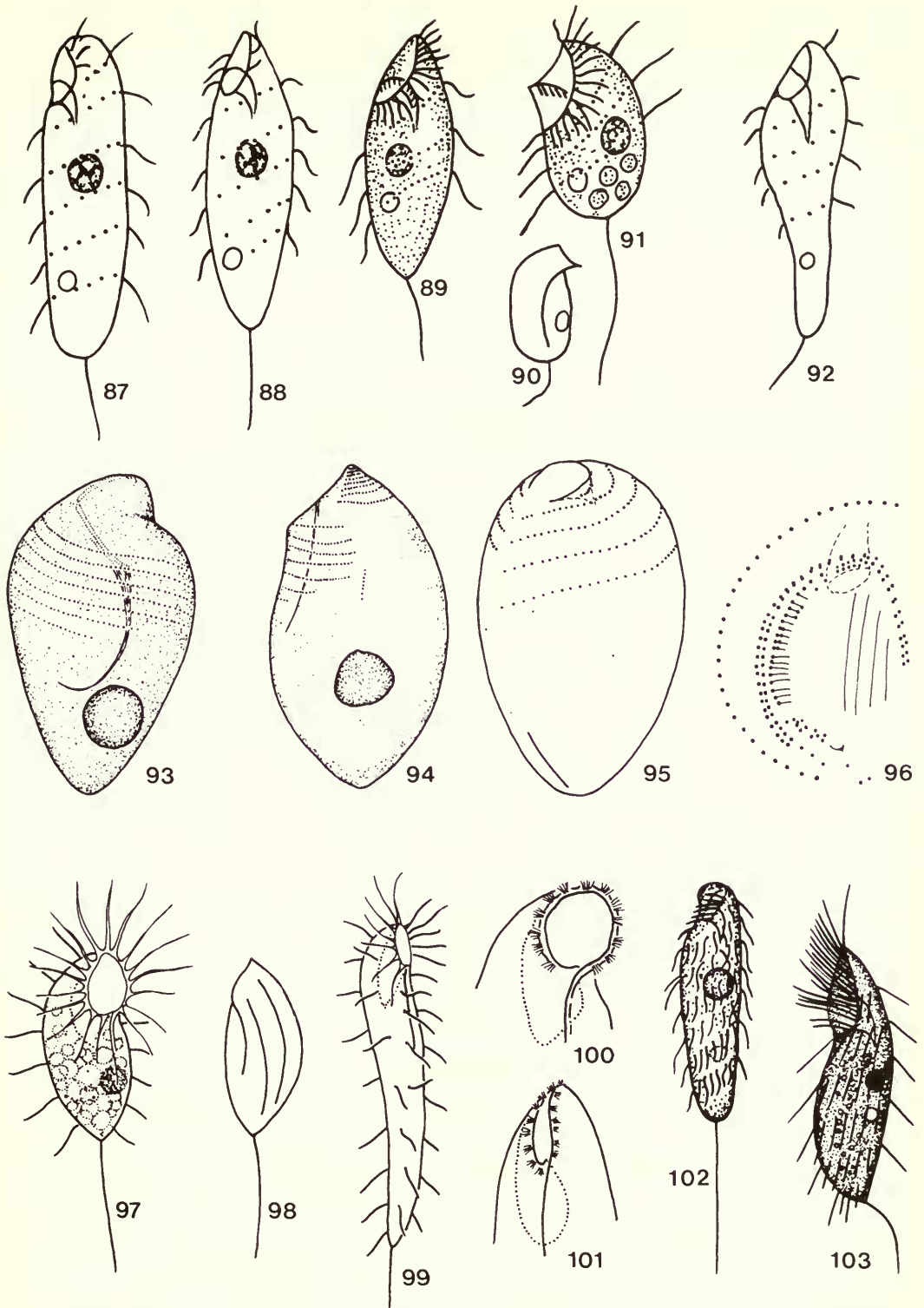
NEOTYPE-SPECIMENS. Slides (dry silvered and protargol silver impregnated) of neotype-specimens have been deposited in the British Museum (Natural History) in London, reference numbers 1986:5:30:2–3.

REDESCRIPTION (Figs 59–86, 104–113, Table 2). Type species of the genus. Freshwater and marine. *In vivo* about 25–50(–60) \times 15–20(–35) μm (Lackey, 1925; Kahl, 1926, 1928, 1931, 1933; Wang & Nie, 1935; Liebmann, 1936; Czapik, 1975*a*; Schmall, 1976; Detcheva *et al.*, 1981). Body fusiform to plump S-shaped, laterally slightly flattened, anterior and posterior end slightly tapered. Dorsally and ventrally an inconspicuous ectoplasmatic ridge, the so-called keel (unrecognized by us) (Kahl, 1926; Wang & Nie, 1935). Macronucleus spherical to slightly oval, located centrally in most specimens. Schmall (1976) found it to be more variable, also located posteriorly. Micronucleus closely attached to the macronucleus. In protargol impregnated specimens often a second, weakly stained macronucleus-like structure, probably a large ingestion vacuole (Fig. 109). Macronucleus usually heavily stained, surrounded by dark, slightly curved rods measuring *c.* 2 μm in length and 0.5 μm in width. These aggregated rods look like bacteria. Detcheva *et al.* (1981), however, consider them to be mitochondria, which is not supported by recent studies on other sapropelic ciliates (Van Bruggen *et al.*, 1984). Contractile vacuole and its pore located in the region of the last ciliary spiral on the right ventro-lateral side. Cytoproct a slit *circa* 5–10 μm long, located in the right dorso-lateral surface (Figs 104, 105, 108). Pellicle thin, flexible and deformable, with very slight ridges paralleling the longitudinal kineties. In protargol impregnated specimens these ridges appear darkly stained and produce a negative image of the silverline system. Cytoplasm rather transparent, contains a lot of refractive long-oval (length about 0.5–1.5 μm) granules which are also visible in protargol stained specimens. They are most probably the mucocysts described by Detcheva *et al.* (1981). Food vacuoles about 5 μm in diameter. Cyclosis pronounced (Lackey, 1925). Feeds on bacteria but is not dependent on sulphur bacteria (Liebmann, 1947). Moves slowly and slightly tremblingly in a straight line or in the arc of a circle rotating on its longitudinal axis (Lackey, 1925). Reproduction by transverse fission (Lackey, 1925; Kahl, 1926, 1931; Czapik, 1975*a*).

Somatic cilia 7–9 μm , strongly beating, arranged in about 50–60 longitudinal kineties but more commonly viewed as 3 oblique spirals. In the anterior region of these spirals the third, fourth, and fifth kinetosomes are paired, constituting the compact field of cilia, consisting of 3 \times 4 and 2 \times 2 cilia, described by Schmall (1976) (Figs 75, 113). A short row of about 5–10 cilia on the ventral side extends obliquely from the posterior end of the anteriormost somatic spiral to the right. Posterior



Figs 77–86 *Trimyema compressa*. 77–79 After Jankowski (1964). 77 From life (inverted). 78 Left lateral view of a dry silver impregnated specimen. 79 Lateral view of a dry silvered specimen (inverted). 80–82 After Czapik (1975a), specimens stained by Chatton's method as modified by Corliss. 80 Scheme representing the disposition of the ciliary spirals. 81 Ventro-apical region. 82 Ventral side (Czapik called it right side). 83 After Detcheva *et al.* (1981), dorsal view (inverted). 84–86 After Fauré-Fremiet (1962) who identified it erroneously as *T. marina*. 84 From life. 85 Apical view of Chatton-Lwoff impregnated specimen. 86. Infraciliature and silver lines of left dorso-lateral side of a Chatton-Lwoff impregnated specimen (Fauré-Fremiet interpreted it as left ventro-lateral view).



third of body unciliated apart from the caudal cilium measuring about one third to one half of body length (Lackey, 1925; Kahl, 1931; Wang & Nie, 1935); it is perhaps involved in the process of defecation (Liebmann, 1936) (Figs 62–65).

Vestibulum *circa* one third of body length, funnel-shaped. Left half of the oral depression more excavated than the right one and, as a consequence, the left margin becomes a thin, transparent layer of ectoplasm and forms a cap or hood-like process bordering the vestibulum (Kahl, 1926; Wang & Nie, 1935). Cytopharyngeal fibres inconspicuous, rectangular to the entrance of the vestibulum. Vestibular kinety 1 a bit longer than vestibular kinety 2. At their anterior ends 4 to 5 pairs of basal bodies or single basal bodies with parasomal sacs. Vestibular kinety 3 consists of only 6–7 cilia (Figs 107, 111, 112). In stained specimens somatic as well as vestibular kinetosomes appear to be paired (Figs 106–113) but in fact, the anterior granule is a parasomal sac (Detcheva *et al.*, 1981), probably with the exception of the above mentioned compact field.

About 60 longitudinal silver lines (Czapik, 1975*a* mentioned 52 lines), connected by transverse lines which are located between the somatic ciliary spirals. In front of the anteriormost ciliary spiral a circumoral silver line from which a few longitudinal lines extend to the vestibulum forming square-like fields at its rim. The longitudinal silver lines fuse at the posterior third forming rough meshes (Figs 106, 110).

OCCURRENCE AND ECOLOGY. First recorded from the sewage disposal of Imhoff tanks in New Jersey and later listed as an obligate anaerobe (Lackey, 1925, 1938; Noland & Gojdics, 1967). Very similar habitats were reported by Liebmann (1936, 1947, 1951), who found *T. compressa* regularly in waters containing a lot of organic matter and H₂S, such as in over-loaded percolating filters, in Imhoff tanks (3–5 ind.ml⁻¹ and 40 ind.ml⁻¹), in sewers, and at the outfalls of communal waste waters.

Further habitats are the sapropel of ponds near Leningrad (Jankowski, 1964*a,b*), ponds used for the treatment of sugar factory wastes (Grabacka, 1973), the plankton of the eutrophic pond 'Poppelsdorfer Weiher' in Bonn (Wilbert, 1969), a small eutrophic lake at Uttendorf/Salzburg (Foissner, unpublished), and an arctic tundra pond at Barrow/Alaska (Fenchel, 1975). Detcheva (1972) and Czapik (1975*a,b*) listed up Bulgarian and Polish habitats like ponds, lakes, ditches, and polluted rivers. Wang & Nie (1935) observed some individuals among decaying organic substances taken from Lake Ho Hu. Kahl (1926, 1931, 1933) found it in the sapropel, in a cesspool, in sewage, and more rarely in the brackish waters of Oldesloe (Kahl, 1928) thus considering it to be of freshwater origin. Fauré-Fremiet (1962) found it in a rock pool on the French Atlantic coast. Tucolesco (1962*b*) recorded it from the Black Sea and from the saliferous, para-marine Lake Tekirghiol in Roumania. According to Sládeček (1972) *T. compressa* developed in great numbers (up to 10,000 ind.ml⁻¹) in a sample of industrial waste water from a textile factory.

Figs 87–103 *Trimyema*.

Figs 87–89 *Trimyema marina*. **87, 88** After Kahl (1933). **89** After Kahl (1931).

Figs 90, 91 *Trimyema minuta* after Kahl (1931), dorsal and left lateral view.

Fig. 92 *Trimyema claviformis* after Kahl (1933).

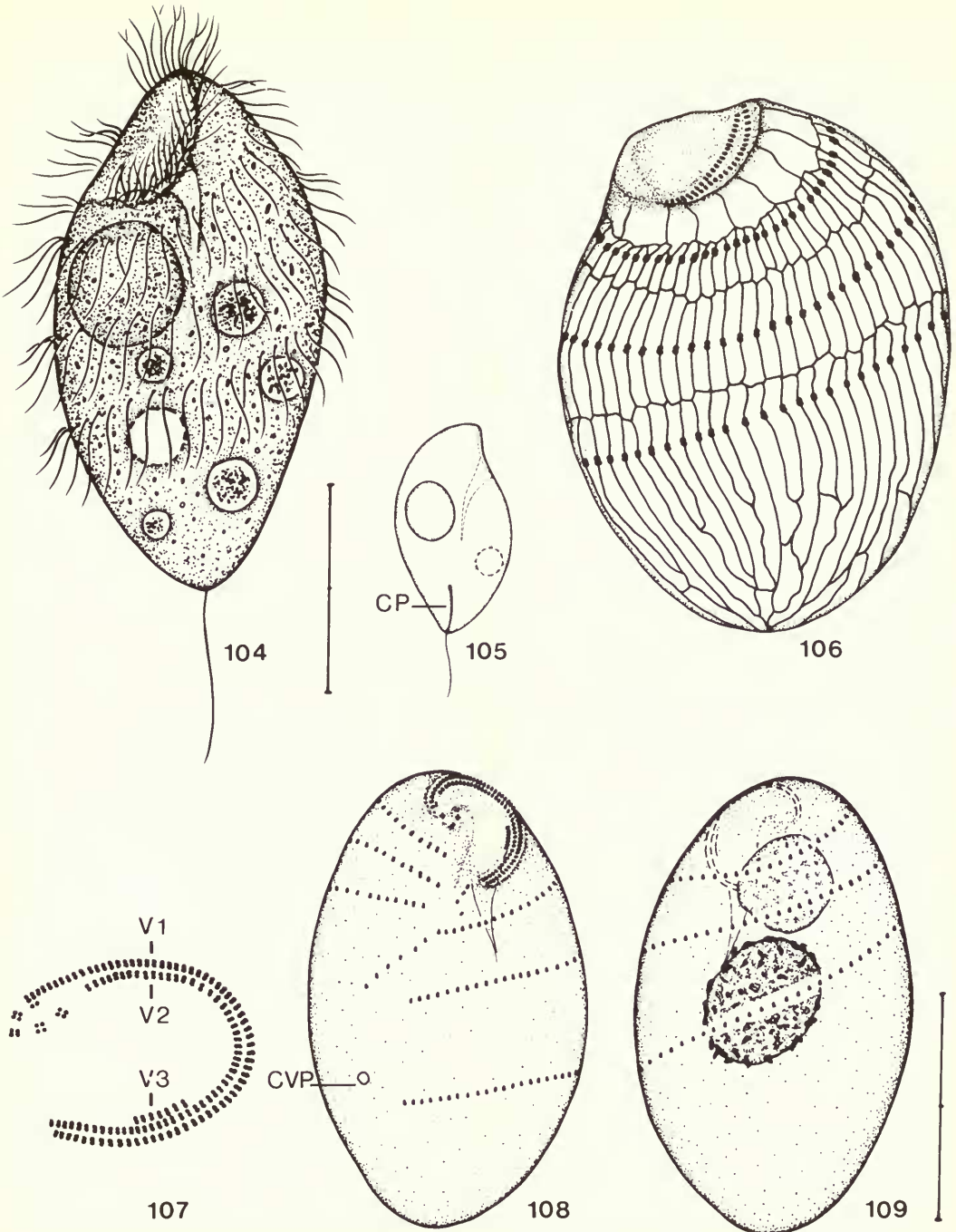
Figs 93, 94 *Trimyema echinometrae* after Grolière *et al.* (1980), protargol silver impregnated specimens (inverted), lateral view and ventral view (the latter designated as lateral view, too).

Figs 95, 96 *Trimyema pleurispiralis* after Borror (1972). **95** Left ventro-lateral view. **96** Anterior pole with anteriormost somatic ciliary spiral (at the left) and with vestibular ciliature.

Figs 97–101 *Palmarium salinum* Gajevskaja after Ruinen (1938). **97, 98** Normal form, ventral and dorsal view. **99** Slender (abnormal?) form. **100, 101** Peristome, ventral and lateral view.

Fig. 102 *Trimyema alfredkahli* after Tucolesco (1962*a*), left lateral view.

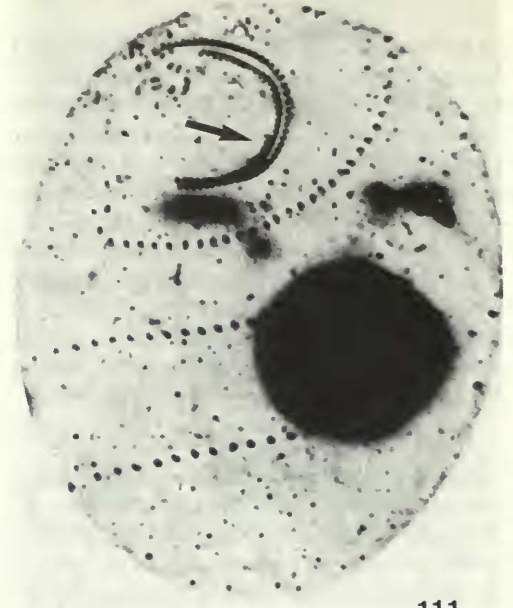
Fig. 103 *Trimyema kahli* after Tucolesco (1962*a*), left lateral view.



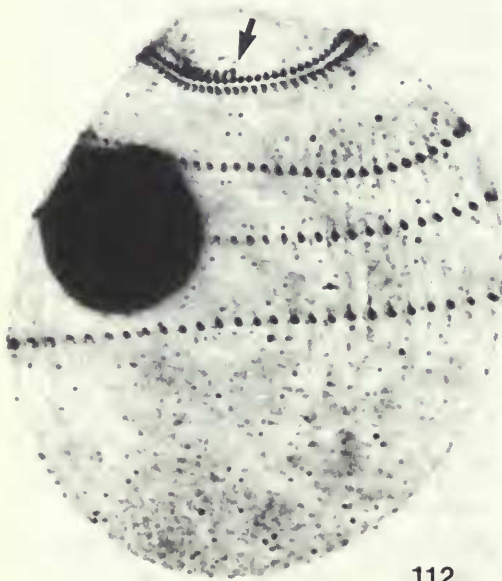
Figs 104–109 *Trimyema compressa*, originals, scale = 20 μ m each. **104** Left ventro-lateral view, from life. **105** Right dorso-lateral view of an S-shaped individual. CP, cytoproct. **106** Dorsal view of a dry silvered specimen. **107** Vestibular ciliature revealed by Fernandez-Galiano's method. The shape of the vestibular kineties has been slightly deformed by preparation; they are less curved in life. V1–3, vestibular kineties 1–3. **108**, **109** Ventral and dorsal view of a protargol silver impregnated specimen amended with details from individuals impregnated with Fernandez-Galiano's method. CVP, contractile vacuole pore.



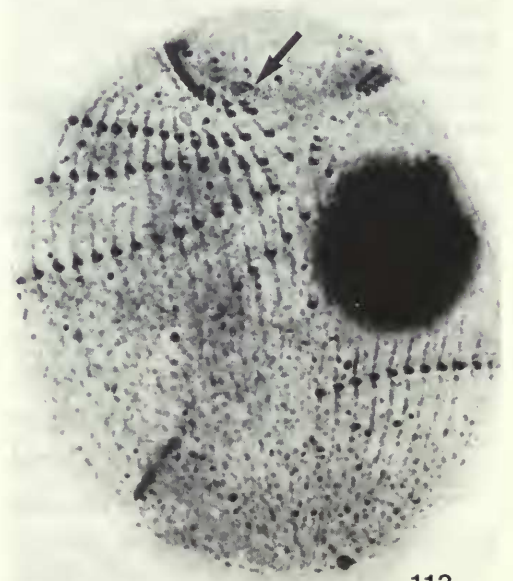
110



111



112



113

Figs 110–113 *Trimyema compressa*. **110** Silverline system revealed by the dry silver impregnation technique, dorsal view. **111–113** Specimens stained by Fernandez-Galiano's impregnation technique. **111** Left side with the three ciliary spirals and apex with vestibular ciliature consisting of two long rows and one short row of cilia (arrow). **112** Dorsal view, arrow indicates the three vestibular kineties. **113** Ventral view, arrow indicates the isolated basal bodies at the anteriormost region of the vestibular kineties.

Bick (1968, 1972) gave the most detailed ecological characterization. *T. compressa* is an outstanding indicator of polysaprobity (Liebmann, 1951), isosaprobity and even metasaprobity (Sládeček, 1973) and occurs in waters receiving fresh manure and sewage, or waste waters containing cellulose material (paper mill outlets, etc.). The species seems to prefer conditions with low ammonia content, i.e. conditions prevailing during the decay of cellulose and other material poor in nitrogenous compounds. The saprobiological evaluation is indicated by Sládeček (1972): $x=0$, $\sigma=0$, $\beta=0$, $\alpha=0$, $p=10$, $G=5$, $s=5.3$ (E, H₂S).

REMARKS. This species differs from *T. minuta* particularly by the tapered posterior end. It can easily be distinguished from the other species by its having only three somatic ciliary spirals. Fauré-Fremiet (1962) observed an abundant population of *Trimyema* (Figs 84–86) and identified it as *T. marina* although it was of an ovoid and stocky form which was not described by Kahl (1931, 1933, 1935). On the contrary this author later stated that *T. marina* is usually one third to one half more slender than he drew it in 1931 (Kahl, 1931, Fig. 89; Kahl, 1933, Figs 87, 88). Thus we suppose that Fauré-Fremiet worked on *T. compressa*.

Table 2 Biometrical characterization of *Trimyema compressa*

Character ¹	\bar{x}	M	SD	SE	CV	Min	Max	n
Body, length	39.05	39.5	4.58	1.03	11.7	32.0	47.0	20
Body, width	22.30	23.0	3.01	0.67	13.5	17.0	26.0	20
Macronucleus, length	11.05	11.0	1.57	0.35	14.2	9.0	14.0	20
Macronucleus, width	9.35	9.5	1.50	0.34	16.0	6.0	12.0	20
Number of vestibular ciliary rows	3.00	3.0	0.00	0.00	0.0	3.0	3.0	20
Number of somatic ciliary rows	3.00	3.0	0.00	0.00	0.0	3.0	3.0	20
Number of caudal cilia	1.00	1.0	0.00	0.00	0.0	1.0	1.0	20
Distance from apex to posterior end of vestibulum	9.80	10.0	1.88	0.42	19.2	7.0	15.0	20
Distance between posterior end of body and posterior end of ciliary spirals	11.00	11.0	1.78	0.40	16.2	7.0	15.0	20

¹See footnote Table 1

Trimyema alfredkahli Tucolesco, 1962a

DIAGNOSIS (Fig. 102). Marine. About 60 μm . Body oblong and slender, slightly tapering anteriorly and posteriorly. Oral apparatus particularly small, bounded at the right margin by a conspicuous dilatation. Macronucleus spherical. Cilia long and fine. According to Tucolesco's figure ciliary spirals cover nearly the whole body, which contrasts his description. Caudal cilium longer than half body length.

OCCURRENCE AND ECOLOGY. Found in an abundant population in a mixed polysaprobic culture taken from the Black Sea in March 1955.

REMARKS. This species has remained unmentioned since description. It can perhaps be distinguished from *T. marina* by its oblique orientation of the oral apparatus, which is stressed by Tucolesco (1962a), and by its larger size. However, synonymy cannot be excluded.

Trimyema claviformis Kahl, 1933

Trimyema claviforme Kahl, 1933

DIAGNOSIS (Fig. 92). Marine. Circa 40 μm . Body club-shaped. Posterior third of body unciliated.

OCCURRENCE AND ECOLOGY. Found in sapropelic habitats of Sylt and Kiel (Germany).

REMARKS. Very insufficiently described. With exception of the unciliated tapering posterior third of body identical with *T. marina*. Even Kahl (1935) noted that he established this species with some doubt. Thus, synonymy cannot be excluded.

Trimyema echinometrae Grolière, Puytorac & Grain, 1980

DIAGNOSIS (Figs 93, 94). Marine. Living endocommensally in sea-urchins. About 31 (27–40) × 17 (13–20) µm. Body peg-top like. Macronucleus spherical, 5–7.5 µm in diameter, posteriorly located. Micronucleus not visible. 60 to 70 longitudinal somatic kineties. Cilia distributed in 7 parallel spirals in the anterior half of body. Three vestibular kineties very similarly arranged as in *T. compressa*.

OCCURRENCE AND ECOLOGY. Found in the sea-urchins *Diadema antillarum* and *Echinometra lucunter* from the Gulf of Mexico and the Gulf of Guadeloupe. Housing together with other commensal species like *Biggaria echinometris*, *Metanophrys elongata* and *Metopus circumlabens* (Grolière *et al.*, 1980). Perhaps already Profant (1966) observed this species, since he mentioned *Trimyema sp.* to be a ciliate inhabiting echinoids in the Eastern Pacific Ocean.

REMARKS. *T. echinometrae* is a reliable species. It differs from the other members of the genus in the number of ciliary spirals. The figures, however, are obviously inverted, because in the genus *Trimyema* the spirals run the other way round. Furthermore, the identification is impeded by the missing drawing from life.

Trimyema kahli Tucolesco, 1962a

DIAGNOSIS (Fig. 103). Para-marine. About 36–40 µm. Body conspicuously asymmetric, inverted S-shaped. Peristome in the anterior third of body. Macronucleus spherical, usually located in the middle of the cell. Contractile vacuole close behind the middle of body. Cilia long and fine. Ciliary spirals extending to the posterior pole. Caudal cilium almost rigid, bent to the left.

OCCURRENCE AND ECOLOGY. Polysaprobic, found constantly in the para-marine Roumanian Lake Tekirghiol (Tucolesco, 1962a,b).

REMARKS. This species has remained unmentioned since 1962. However, from its general appearance it seems to be a reliable but insufficiently described species.

Trimyema marina (Kahl, 1931)

Sciadostoma marinum Kahl, 1931

Trimyema marinum Kahl, 1933

DIAGNOSIS (Figs 87–89). Marine. About 40 µm. Slender fusiform to slender oblong (4 : 1). In the original figure (Fig. 89) similar to *T. compressa* but later figured and redescribed with 5–6 ciliary spirals (Figs 87, 88).

OCCURRENCE AND ECOLOGY. Repeatedly observed in putrid water of the North and East Sea (Sylt, Kiel) and in salt-water from Oldesloe (Kahl, 1931, 1933, 1935).

REMARKS. Kahl (1931) considered *T. marina* to be a separable species because he never found similar forms among numerous populations of the freshwater form of *T. compressa*. Later he thought that two forms of this species probably exist and erected the species *T. claviformis* (Kahl, 1933) which, however, is not a totally reliable species (Kahl, 1935). We consider this species and *T. alfredkahli* perhaps to be junior synonyms of *T. marina*.

Trimyema minuta nov. comb.

Sciadostoma minutum Kahl, 1931

DIAGNOSIS (Figs 90, 91). Freshwater and marine. About 20 µm. Rounded posterior and a prominent beak-like pharynx-opening. Ectoplasmatic ridge (keel) more pronounced than in *T.*

compressa, extending from the beak-like pharynx-opening over the back to the posterior. Cilia longer and more rigid than in *T. compressa*.

OCCURRENCE AND ECOLOGY. This species was found together with *T. compressa* and was first considered as a modification, but once an abundant population occurred in a ditch contaminated with liquid manure (Kahl, 1931). Wenzel (1961) observed *T. minuta* in the sponge *Halichondria panicea* from the Gulf of Naples. Tucolesco (1962*b*) recorded it twice from old, mixed infusions of the para-marine Roumanian Lake Tekirghiol.

REMARKS. Kahl (1931) doubted the species status of this form and did not mention it again in his publication of the year 1935. Further investigations are necessary.

Trimyema pleurispiralis Borror, 1972

DIAGNOSIS (Figs 95, 96). Marine. About 20–44 × 16–23 (usually less than 20) μm. Shape of prepared individuals egg-like, circular in cross section (Fig. 95). Macronucleus spherical, central. Micronucleus not observed. Cytoproct an elongated (approximately 8 μm) slit near posterior pole, lying in the same latitude as cytostome and suture at ends of ciliary spirals. Contractile vacuole pore not observed. Except for elongated caudal cilium, all somatic cilia restricted to anterior half of cell, arranged in at least four spirals (a few individuals possess a partial or even complete fifth spiral, and even a few cilia of a sixth spiral). Outer vestibular kinety in a semicircle dipping posteriorly into vestibulum and terminating near cytostome. Inner vestibular kinety with three regions: (1) anteriormost two isolated tufts of approximately five cilia each, (2) a row of kinetosomes closely paralleling the outer kinety, extending from the tufts down to cytostome, (3) posteriormost a J-shaped field of cilia. As already mentioned, this interpretation of the oral structure is a little erroneous and incomplete.

OCCURRENCE AND ECOLOGY. Like the other species of this genus *T. pleurispiralis* is bacterivorous and occurred only irregularly in New Hampshire tidal salt marshes (Borror, 1972).

REMARKS. This species differs from the other members of the genus in number and location of ciliary spirals, which are restricted to the anterior half of body. Unfortunately, Borror (1972) did not give a drawing from life. Thus, the real body shape is unknown. Redescription is needed.

Genus *TROCHILIOPSIS* Penard, 1922

DIAGNOSIS. Microthoracidae Wrześniowski, 1870 with cytostome in the anterior third of body. Three preoral kineties subapically on the left body side. Somatic kineties from either side terminate near the pointed beak-like region formed by the oral structures. Apex smooth. Rightmost somatic kinety of the right side interrupted. Contractile vacuole located almost centrally. Freshwater, polysaprobic.

TYPE-SPECIES. *Trochiliopsis opaca* Penard, 1922.

REMARKS. *Trochiliopsis* shows many characters which are very likely homologous to genera of the family Microthoracidae Wrześniowski 1870 according to the classification of Foissner (1985*b*). Thus, a separation of *Trochiliopsis* at the familial level as suggested by Jankowski (1975) is not justified (Compare Corliss, 1979; Curds, 1982). On the contrary, the organization of *Trochiliopsis*, especially the general appearance of the infraciliature and the location and structure of the oral apparatus, allows a classification close to the genus *Stammeridium*. These similarities might have induced Kahl (1931) to synonymize *Trochiliopsis* with *Trichopelma* Levander and *Leptopharynx* Mermod. There are just sufficient differences in the location of the preoral kineties, the paroral membrane, and the shape of the anteriormost region for separating these two genera. Furthermore, by a trivial twist of some organelles of *Trochiliopsis*, the typical organization of the genus *Stammeridium* can be achieved (Figs 126, 127): The preoral kineties move to the apex between serrated processes, the paroral membrane gets located obliquely to the longitudinal axis and the contractile vacuole moves close to the ventral side.

Key to the genera of *Microthoracina* Jankowski 1967 (based on Foissner 1985b)

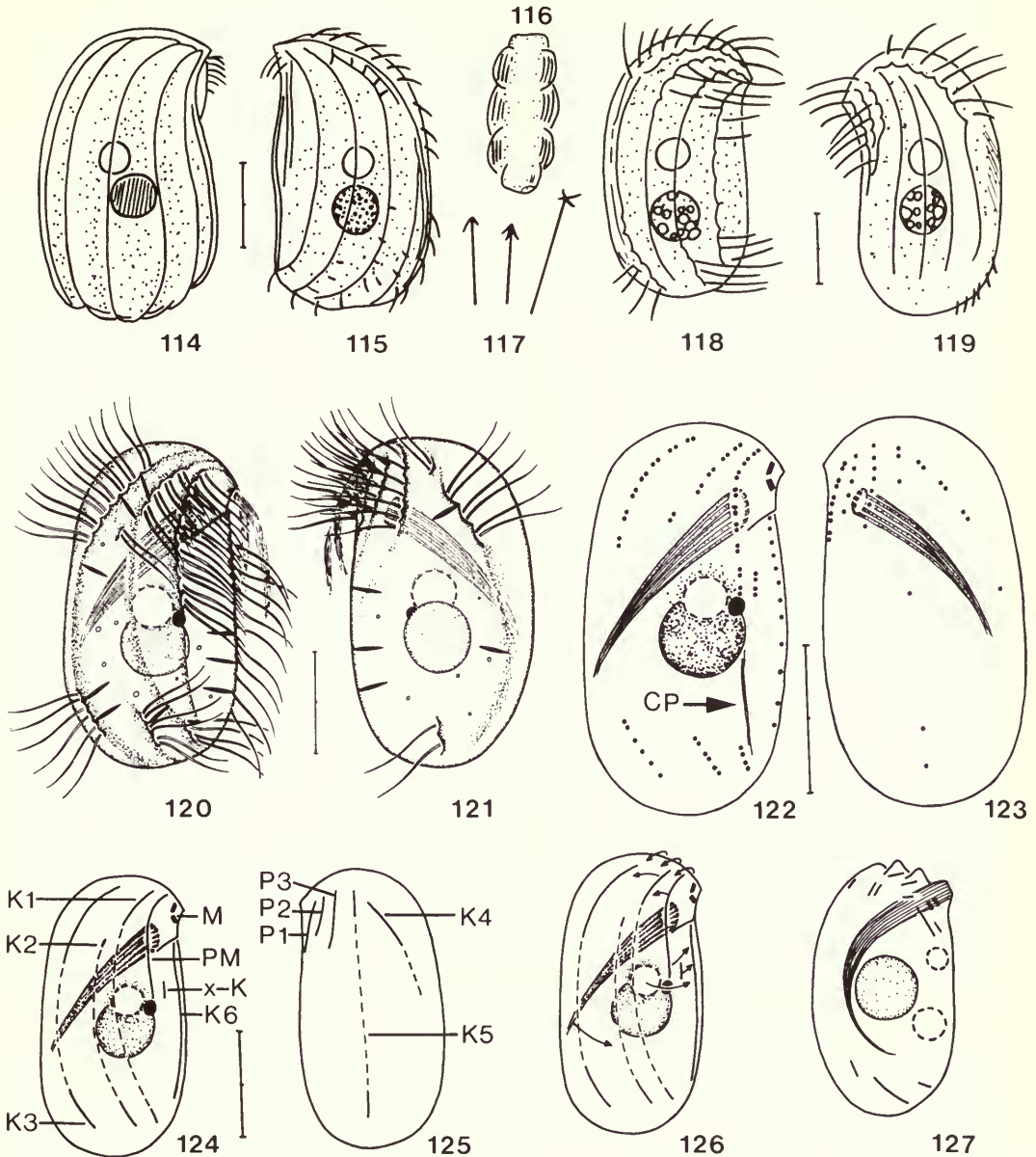
- 1a *Microthoracina* with somatic cirri-like organelles, fusiform extrusomes, and wide-meshed silverline system (Discotrichidae) ***Discotricha***
- 1b *Microthoracina* with normal cilia, anchor-like extrusomes, and granular or fine-meshed silverline system 2
- 2a *Microthoracina* with more than 10 uninterrupted somatic kineties (Pseudomicrothoracidae) ***Pseudomicrothorax***
- 2b *Microthoracina* with fewer than 10, usually 6 partly interrupted somatic and three preoral kineties (Microthoracidae) 3
- 3a Oral apparatus ventrally in the posterior third of body ***Microthorax***
- 3b Other 4
- 4a Oral apparatus ventrally between middle and posterior third of body, body more or less oblong ***Drepanomonas***
- 4b Other 5
- 5a Oral apparatus between middle and anterior third of body, rightmost somatic kinety or right side uninterrupted, preoral kineties run in distinct furrows from the ventral to the right body side and form a keel ***Leptopharynx***
- 5b Other 6
- 6a Rightmost somatic kinety of right side interrupted, preoral kineties run anterior-posteriorly on the left side of the body, paroral membrane *circa* half body length ***Trochiliopsis***
single species: ***Trochiliopsis opaca***
- 6b Preoral kineties apically in furrows, apex distinctly serrated, paroral membrane shorter than a third of body running obliquely to the longitudinal axis ***Stammeridium***
single species: ***Stammeridium kahli***

Description of species***Trochiliopsis opaca* Penard, 1922***Trichopelma opaca* Kahl, 1931*Leptopharynx opaca* Detcheva, 1972

NEOTYPE-SPECIMENS. Slides (protargol silver impregnated and dry silvered) of neotype-specimens have been deposited in the British Museum (Natural History) in London, reference numbers 1986:5:30:4–5.

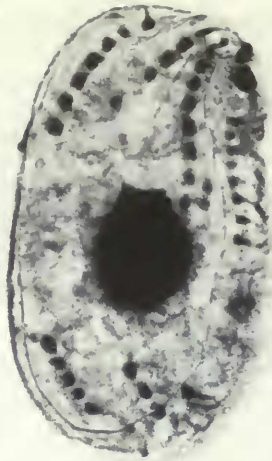
REDESCRIPTION (Figs 114–131, Table 3). Type species of the genus. Freshwater. *In vivo* *circa* 30–40(–50) × 17–20 µm. Body outline oval, anteriorly curved slightly to the ventral side terminating in a pointed beak-like region (peak). Body strongly compressed laterally (*circa* 2 : 1). Somatic kineties in deep, crenelated furrows, which terminate near the oral peak. Macronucleus spherical, more or less centrally located, *in vivo* hardly discernible. Micronucleus closely attached to the macronucleus. Contractile vacuole centrally located, close to the right lateral surface, diameter about 4 µm; contractile vacuole pore at the end of the paroral membrane. Cytoproct slightly posterior to the contractile vacuole pore, visible as black line in dry silvered specimen (Fig. 130). Pellicle rigid, colourless, opaque. Extrusomes about 3 µm, fusiform, scattered over the whole body in the ribs between the furrows, show four anchor-like processes at the distal end in the exploded phase. Probably feeds on bacteria, but no food vacuoles were found. Slow, trembling and swaying movements.

Length of cilia 8–10 µm. Six somatic kineties (K1–6), three preoral kineties (P1–3), and a short x-kinety (Figs 124, 125). K1 anterior with 8–10, posterior with 4, K2 anterior with 2, posterior with 5–6, K3 anterior with 12–16, posterior with 5–8, K4 (anterior) with 6–8, K5 anterior with 3–4, posterior with 2, K6 with 10–12 kinetosomes. At the end of K4 and in the middle of K5 sometimes a single unciliated kinetosome, respectively. Basal bodies of K1–5 mostly paired, K6 always with single kinetosomes. Preoral kinety 1 with 4–5 pairs, preoral kinety 2 constantly with 5 singles, and preoral kinety 3 constantly with 7 singles. x-kinety with 1–2 paired basal bodies located left of the posterior end of the paroral membrane (Figs 120–126).

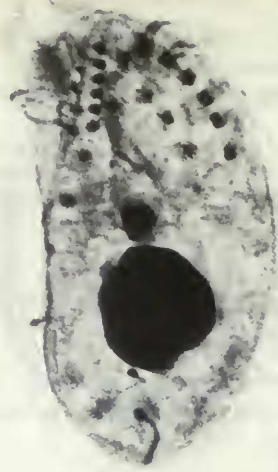


Figs 114–126 *Trochiliopsis opaca*, scale = 10 µm each. 114–117 After Penard (1922). 114, 115 Right and left lateral view. 116 View from the apex. 117 Extrusomes with 2, 3, and 4 processes. 118, 119 After Kahl (1931), right and left side. 120–123 Originals, from life and protargol silver stained specimens, right and left side respectively. CP, cytoproct. 124, 125 Schematized organization of *T. opaca*, right and left lateral view. K1–6, somatic kineties 1–6; M, adoral membranelles; PM, paroral membrane; P1–3, preoral kineties 1–3; x–K, x-kinety 126 Probable evolution of *Stammeridium* from *Trochiliopsis*.

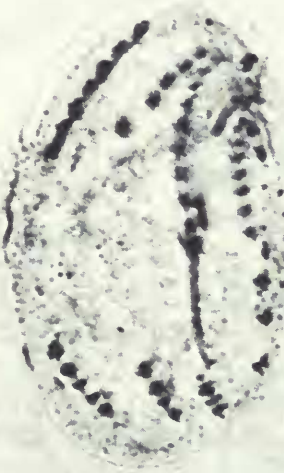
Fig. 127 Schematic organization of the genus *Stammeridium* (after Foissner, 1985b).



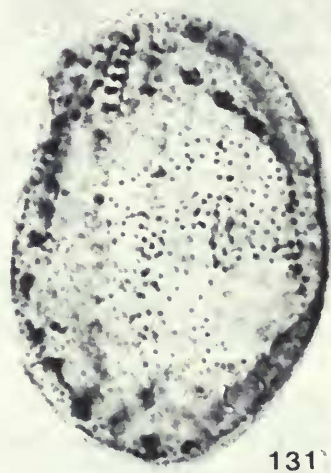
128



129



130



131

Figs 128–131 *Trochilopsis opaca*. 128, 129 Protargol silver impregnated specimens, right and left side.
130, 131 Dry silver impregnated specimens, right and left side.

Probably only two adoral membranelles, located at the oral peak. Anterior adoral membranelle most likely built up by two rows, posterior one probably by three rows of kinetosomes. Paroral membrane with 8–9 paired basal bodies (Figs 120, 122, 124). Cyrtos invisible in life even with interference contrast, but slightly impregnated with protargol silver.

Silverline system granular or very fine-meshed.

OCCURRENCE AND ECOLOGY. Penard (1922) found few individuals between dead leaves of the 'swan pond' at Ariana ('... à l'étang des Cygnes', Switzerland). Kahl (1931) noted *T. opaca* sporadically in the sapropel and sometimes numerous in sapropelic infusions of *Glyceria*. Lackey (1938) recorded it once from a polluted stream, twice from a trickling filter, and five times from an activated-sludge chamber. Noland & Gojdics (1967) mentioned that *T. opaca* occurs when the sludge has reached the finely particulate stage and the bacteria in it are well distributed. Detcheva

(1972) listed some Bulgarian habitats, namely a pond in the surroundings of the village Bosnek in the Witoscha mountains, a marshy meadow in the vicinity of the village Kasitschene near Sofia, and a river in the Wrâbniza quarter of Sofia. Apart from in activated sludge, we found this species once in the polysaprobic zone of a heavily polluted river (Ager near Lenzing, Upper Austria). These localities suggest *T. opaca* to be a good indicator of heavily polluted (polysaprobic) conditions. It might also have some tolerance of H₂S.

Table 3 Biometrical characterization of *Trochilopsis opaca*

Character ¹	\bar{x}	M	SD	SE	CV	Min	Max	n
Body, length	25.66	26.0	1.12	0.37	4.4	24.0	27.0	9
Body, width	13.22	13.0	0.83	0.28	6.3	12.0	15.0	9
Macronucleus, length	6.33	6.5	0.35	0.12	5.6	6.0	7.0	9
Macronucleus, width	6.11	6.0	0.42	0.14	6.8	5.5	7.0	9
Distance from apex to the beginning of macronucleus	12.22	12.0	1.30	0.44	10.6	10.0	14.0	9
Micronucleus, length	1.62	1.6	0.30	0.10	18.7	1.2	2.0	9
Micronucleus, width	1.51	1.5	0.31	0.10	20.8	1.0	1.8	9
Number of kinetosomes of paroral membrane	17.78	18.0	0.67	0.22	3.7	16.0	18.0	9
Number of kinetosomes of anterior kinety 1	8.22	8.0	0.67	0.22	8.1	8.0	10.0	9
Number of kinetosomes of posterior kinety 1	4.00	4.0	0.00	0.00	0.0	4.0	4.0	9
Number of kinetosomes of anterior kinety 2	2.00	2.0	0.00	0.00	0.0	2.0	2.0	9
Number of kinetosomes of posterior kinety 2	5.89	6.0	0.33	0.11	5.7	5.0	6.0	9
Number of kinetosomes of anterior kinety 3	13.11	12.0	1.45	0.48	11.1	12.0	16.0	9
Number of kinetosomes of posterior kinety 3	6.11	6.0	0.93	0.31	15.2	5.0	8.0	9
Number of kinetosomes of kinety 4	6.67	6.0	0.87	0.29	13.0	6.0	8.0	9
Number of kinetosomes of anterior kinety 5	3.11	3.0	0.33	0.11	10.7	3.0	4.0	9
Number of kinetosomes of posterior kinety 5	2.00	2.0	0.00	0.00	0.0	2.0	2.0	9
Number of kinetosomes of kinety 6	10.33	10.0	0.71	0.24	6.8	10.0	12.0	9
Number of kinetosomes of the x-kinety	3.78	4.0	0.67	0.22	17.6	2.0	4.0	9
Number of kinetosomes of preoral kinety 1	9.89	10.0	0.33	0.11	3.4	9.0	10.0	9
Number of kinetosomes of preoral kinety 2	5.00	5.0	0.00	0.00	0.0	5.0	5.0	9
Number of kinetosomes of preoral kinety 3	7.00	7.0	0.00	0.00	0.0	7.0	7.0	9

¹See footnote Table 1

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